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Summary

In the past decades, cognitive research has resulted in a vast amount of empirical findings on the nature, organization and development of students' knowledge. This new understanding allows scientifically based curriculum development, which is not the case in many educational systems yet. This paper argues for a more sophisticated and differentiated conception of knowledge for educational design and evaluation. It identifies the organizing principles, which create durable and working cognitive systems out of the distinct elements like facts, figures and skills. Three different types of knowledge organization are discussed and compared: expertise, determined by the values of a profession or discipline; literacy, the broadly applicable and socially valuable knowledge; and competence, that is still a vague, but on the long run a promising conception for education.

Introduction

The changes in the way we look at knowledge brought about corresponding changes in education-related research and in some countries even in the practice of teaching in the last pre-millennial decade. To the public these changes were indicated by the international knowledge measurements of the recent years in a sometimes shockingly vivid manner. Therefore, if one wants to survey the changes in conceptions about knowledge, it is inevitable to refer to the results of these measurements and their scientific background.
The unfavourable and sometimes decidedly stunning results of the recent measurements came as a surprise even to a part of the professional community, which resulted in numerous misinterpretations, reflecting superficiality, lack of proper informedness, and an attempt to bagatellise problems. At the same time it must be seen that these international measurements were stemming from the theoretical developments of the past decades, and similar Hungarian works – based on the same theoretical grounds – had described the problems related to our learners' knowledge before, in a more detailed, and sometimes more drastic manner.

In this study I make an attempt to survey this problem as follows: I will begin by giving a brief survey of the theoretical framework in which the changes occurred in our conception of knowledge can be interpreted. I will present some key concepts of contemporary educational research – such as *knowledge, learning, and the environment of teaching and learning* – while also making an attempt to show how the interconnections between these might be seen in a novel way. Following this, I will deal with the main ways in which knowledge is organized in some detail. What I would like to emphasize in this section is that validity of knowledge, depth of understanding, transferability, applicability, usefulness and meaningfulness are determined not only by the extent of elements (propositional and procedural knowledge[1], or factual knowledge and skills, to put it in a traditional terminology), but even more so by the level of organization within the system. The organization of knowledge – if the systematisation of insulated elements ever happens – can work according to numerous different principles. Among other factors, understanding the difference between these organizing principles is what can help us understand the differences between *expertise (expert knowledge), literacy* and *competence*, thus rendering the problems of our students' knowledge manageable.

Theoretical framework

First of all, I would like to present a theoretical framework in which the notion of 'competence' best fits. About 1960 changes began in psychology and related disciplines, which today we often refer to as 'the cognitive revolution'. Looking back from a few decades' distance we can now tell that the aspirations of the era have really resulted in revolutionary changes, and not only in psychology[2]. A new branch of sciences appeared known as *cognitive science,* and from the turn of the 1970s and 1980s on the infiltration of the results into the theory of education gradually began. By today the most important directions of research in education conform to this paradigm.
As for practical changes, the situation is a bit different. We cannot forget for a moment that public education is a huge and complex system that cannot be steered with quick and precise movements, like a racing car. To stick to metaphors, this system is rather similar to a heavy ocean-

[1] A number of different terminology exist even in English to name the elements of knowledge, not mentioning the problem that there is not a direct correspondence between the terms of other European languages.
[2] For an excellent summary of the history of this revolution, see Gardner, 1985

cruiser that keeps on moving in the original direction even minutes after turning the steering wheel. To put it clearly, it takes quite some time to see the results of the cognitive revolution in the school practice. It was only in the 1990s that these changes began to be felt internationally, and a real turn in the international comparative surveys could be seen only at the end of that decade. Given the actuality of the subject it is inevitable to mention the PISA assessments. However, I would like to interpret the latest results in a wider perspective, even if in the form of only a few short comments.

It is neither possible for me here to give a detailed interpretation of the notion of 'knowledge', nor even to try to give a definition, for that would really go beyond the limitations of this study. However, I find it necessary to fix here that what we call knowledge is built up of a number of particular elements. By today it is generally accepted to differentiate between two general forms of knowledge, declarative and procedural, that is. *Declarative knowledge* (or: propositional knowledge) – named following the cognitive approach – can be approximately described in the traditional terms as 'lexical knowledge', or 'factual knowledge'. It is a system of interrelated elements. *Procedural knowledge* is the psychic representation of an action or process that would traditionally be termed 'skills', sometimes 'ability'. This dual distinction has been present in philosophy and educational thinking for long, while the terminology of cognitive science renders a new approach possible as well. (See for example Chi, 1987; Case, 1996.)

The above mentioned components, however, are only 'building bricks' within the larger building of knowledge. Of course, by 'only' I do not mean that they are not important. Yet, in this context we must show that above a certain level it is not the mere existence (or non-existence) of these elements that determines the value of learners' knowledge, but the ways and quality of their organization. Even the academic debate on the interpretation of the results of different international assessments centres evolves more around the organization than the existence of the elements. This is clearly because applicability and transferability are matters of organization, which once again leads us to the old principle of system theory: a system is always more than the sum of its elements.

Apart from being a system, it is also important how the particular system is built up, what its organizing principles are and what the basic cohesive force is that organizes the basic elements into a system. However, explicating this would be extremely difficult here, so in what follows I will be dealing with the three main –broadly accepted – organizing principles in detail. What is important to have in mind in connection with *learning* in this context is that it is interpreted as *a process of*

changing of knowledge. It may sound simple and a natural statement, yet it signifies a vast departure from older conceptions. According to this definition, knowledge is not simply an ever-increasing pile of information, but within any kind of learning process knowledge gets altered *as a system.* The alteration has many possible forms; what is important here is that this definition of learning directly clarifies the role of previous knowledge in all learning processes. The most important and most natural form of learning is when learning happens through interaction with the environment. This way of looking at learning means that we accept the fact that learning is always a constructive process, knowledge we never get ready-made from outside, but we are always the ones who create our own knowledge.
However, this approach expects a lot in terms of capability (competences) of teachers.

Organization of knowledge

Within the systematisation of knowledge three main organizing principles are to be differentiated. These principles are not new either; they are rather re-conceptualisations of some old ideas. One is when the system of knowledge unfolds around the logic of a *specific field*. Another possibility is when the organization is determined by *culture,* surrounding social context, and personal interactions. Finally, the most natural organizing force stems from *the psychology of human learning,* that is, the way in which our brain represents the things we know. These principles may be interpreted as three dimensions; any kind of organized knowledge can be situated within this three-dimensional space – this means that each dimension is present in all kinds of organized knowledge, to different extents.
Of course, the psychological characteristics of the individual influence the organization of knowledge. At the same time there are forms of learning that aim at the improvement of the psychological structures themselves. In many cases the natural characteristics of perception determine the structure and form of the knowledge to be formed. It matters, how the brain is 'formatted'. What knowledge can be accepted by the individual brain in a natural and effective way? This is the knowledge we define as *competence.*
In modern societies a considerable amount of knowledge is necessary even for simple matters as dealing with everyday issues, or to be able to take the chances offered by technical civilization and culture, to be able to make responsible decisions in questions related to society and natural environment, to be able to take part in organizing family life and to be

able to cooperate, to fit into society, to understand widely accepted symbolic systems and to feel comfortable with culture. This culturally determined knowledge of social value we call *literacy*.
The knowledge-organizing effect of a particular professional field has been known for long, and also its study has considerable traditions. Ever since crafts, professions, fields and scientific disciplines have been around, they have developed according to a logic and laws of their own. To master a particular profession it is necessary for the individual to have certain elements of knowledge organized in the proper way. The knowledge is focused at a ready-made solution for all kinds of problems. This is a scheme that provides solutions right after the identification of the problem to be solved. This type of knowledge is called *expert knowledge* or in short, *expertise.*
The exact differentiation and comparison of these three ways of organization have but a relatively short history. In colloquial (and sometimes professional) use competence and professional knowledge are frequently used as synonyms; at the same time, those working in relevant research have clear-cut definitions for the three kinds. These three systems of organization result in three different types of knowledge, which determine the optimal forms of learning and the possibilities of application as well. In connection with all this we have to emphasize once more that the value of knowledge is determined not merely by quantitative factors; qualitative factors bear similar importance. One of the most important qualitative factors is organization and the internal and external factors that determine it. Let us now turn to the individual organizing principles and relevant types of knowledge.

Expertise

Expert knowledge (expertise, professional knowledge) was one of the first types of knowledge to be studied by cognitive psychologists. A leading figure of this approach was Herbert Simon, well known as an economist and mathematician as well. One of the most important areas of the field describing human thinking as information processing was the study of the development of expertise. Within this paradigm, many important experiments were conducted that proved to shape the way we think about these questions later on. A basic consideration was comparing the information processing of novices and experts on a given field. The differences examined were related to how novices and experts represent

knowledge, how they organize and integrate knowledge, how they combine elements into larger units[3].

For instance, an interesting experiment was conducted with chess players, which is considered to be a classic today. Among other aspects it was observed how a beginner and a grand master represent situations certain rounds. A very important conclusion of these experiments was that the difference between the novice and the expert is not related to the speed or way of information processing, but in the way they organize what they know. The novice tends to think rather in isolated elements, which results in a great number of (subjectively perceived) solutions, while the expert represents situations in systems, structures and schemes. As it is said, there is a relatively small number of realistic possibilities for an expert, while a novice perceives a multitude of possibilities in the same situation.

Research work during the past few decades has revealed much about the nature of expert knowledge; by today we can tell how it is formed, how it develops, and how it works when it comes to application. Professional knowledge is a well-defined set of organized information, skills and capacities prescribed by the particular field. They are always strongly associated with certain kind of specific content, context, situation and environment. These characteristics have further consequences. One of the positive ones is immediate applicability. Experts are very well aware of all the situations they might face during their professional activity. The grand-master has a short glance at the chessboard and he immediately understands the situation, sees the chances, and he is also able to activate the proper set of solutions straightaway. In most cases, this familiarity means an invaluable advantage, although it has a serious drawback at the same time: such knowledge is extremely specific and therefore hardly transferable to anywhere else.

The development of professional knowledge requires long, complex and specific training. In most fields the techniques of acquiring professional knowledge have developed parallel with the development of the field itself; many fields have long traditions of this kind.

There are many different kinds of professional knowledge, and of course not everybody has even the elements of a particular knowledge of this kind. The development of professional knowledge is more or less independent of the age of the individual. However, in many cases, this type of knowledge has to be founded at an early age, and sometimes the optimalisation takes so long that it necessarily involves some sort of age

[3] This early approach of cognitive psychology is presented for example by Simon (1979) in his classical article.

limit. At the same time, those who have acquired the basics properly can develop their knowledge almost lifelong. Incorporating new experiences is possible even at a relatively older age.

The development of professional knowledge is a cumulative process. It is always possible to add some to the already acquired knowledge. The characteristics of this kind of knowledge are very similar to those of *crystallized intelligence* (Cattell, 1963), described earlier by intelligence research[4]. This crystallized intelligence can be developed throughout the life span, just like we can develop specific parts of our professional knowledge the same way. That is why it is often said that professional knowledge is of an extensive nature, which is best characterised with its 'mass' or 'volume'.

Expert knowledge is highly content-dependent, and transferable within very strict limits, if it is transferable at all. Many examples could be enumerated, as the number of acquirable expertise corresponds with the number of professional fields, hobbies, regular activities exercised by mankind. Surgeons, general practitioners, engineers, pilots, chess players, they all have some sort of specific knowledge, that would scarcely be of use in other professions. A number of rare, special expertises could also be enumerated here, like the expertise of the physicist, the research biologist, the chemist, the historian, or the linguist.[5]

The latter professions are mentioned in order to demonstrate that there is a strong correspondence between certain fields and school subjects and expertises. At the same time it is to illustrate the lamentable fact that in our schools this type of professional knowledge is mostly taught. What our children learn at school is mostly knowledge of the professional kind. If we take a closer look at how professional knowledge is formed, how it develops and the teaching practice of our schools, it shows immediately that in schools children are taught grammar, biology, chemistry, and mathematics as if they were to become professionals in these fields[6]. This finding does not come as a surprise, however, teachers themselves point out clearly that in their opinion 'our schools train 'little scientists''.

[4] The results of intelligence research is best summarized by Carroll, 1993.
[5] For more recent views on expertise see Ericsson & Smith, 1991.
[6] There are considerable differences between the American and the European schooling traditions, the European schools are more content oriented, therefore rather transmitting the expert-type knowledge.

Literacy

Literacy is not a new notion in the study of education. In the past decades numerous definitions have been coined. From the beginning of the 1990s an ever-increasing demand was to be felt for (the definition of) a sort of 'civil knowledge'. This constituted a universal, non-professional type of knowledge that was to appear as an outcome of schooling. This type of knowledge was in the focus of the assessments carried out under the aegis of the International Association for Educational Assessment (Third International Science Study and its repetitions, TIMSS and TIMSS-R etc.) as well[7]. A basic reinterpretation, however, began only within the framework of the theoretical preparatory phase of OECD PISA[8] 2000. Members of the PISA expert groups were selected professionals of particular fields who had previously had experience with the cognitive approach in their work.

Preparatory work for the first PISA cycle (OECD, 2000) began at the end of the 1990s (about 1998). It was about that time that the particular type of knowledge to be studied would be termed 'literacy' in English. Considering the original meaning of the word, it would mean ability to read and write, but PISA experts have broadened the meaning when they defined the concept of reading literacy, scientific literacy and mathematical literacy.[9]

I would like to emphasize once more that the main differences between literacy and expertise lie in their determinedness and organization. It is possible that within the same field of almost the same elements a literacy-type of knowledge is organized in one case and expertise in a different one. As for expertise, the organizing principles of the given field are of crucial importance; in the case of literacy it is the surrounding social context (culture, civilization). In both cases elements are organized into a larger system. However, while expert knowledge – through constant exercise – is optimised for a limited number of similar tasks in similar contexts, literacy is a much more loosely organized phenomenon. In other words, literacy is a less decidedly practical type of knowledge, with a much wider scope. Expert knowledge is maintained, kept applicable and vivid and developed by continuous practice of a

[7] See for example Beaton, Mullis, Martin, Gonzalez, Kelly & Smith, 1996; and Beaton, Martin, Mullis, Gonzalez, Smith, & Kelly, 1996.

[8] The Programme for International Student Assessment (PISA) is a long-term educational evaluation project of the Organization for Economic Co-operation and Development (OECD), started in 2000 and repeated in three-year cycles.

[9] The framework was reshaped significantly for the 2003 measurement cycle. See OECD, 2003a.

profession, while literacy is maintained by continuous interaction with the surrounding social environment.

Literacy is a socially valuable type of knowledge, an amalgamated form of the culturally relevant abilities, skills and contents. Its elements are selected by wide social acceptance, and the knowledge itself proves to be universally useful (even beyond the individual's professional work, that is). Literacy helps individual development, personal self-fulfilment, keeping in touch with others and participation in social processes. Different domains of culture are represented to different extents in the literacy of the individual, but each and every individual literacy is a reflection of the same universal culture. Acquisition of literacy happens through different human media (books, works of art, media, persons) and interaction with the individual's social context, and it cannot be derived simply from nature. Literacy, therefore, cannot be acquired without a human context.

There might be enormous qualitative and quantitative differences between individual literacies. Just like in the case of professional knowledge, acquisition is not age-dependent. There are further, sometimes confusing similarities, which include cumulative nature and a possibility of lifelong extension. The content-dependence of literacy is at a medium level, which is a bit more difficult problem that would require further clarification. Generally this means that literacy *is* transferable (not strictly tied to a given context), within certain limits. Furthermore, literacy is rather of an extensive nature, consisting mostly of declarative knowledge.

Today declarative knowledge is frequently seen as something of secondary importance. Therefore, I would like to emphasize here, that integration into culture and participation in social processes in a democratic society is impossible without a huge amount of this type of knowledge[10]. Everybody needs up-to-date, useful knowledge that is relevant to everyday life. In fact, it is declarative knowledge that provides the basis for shaping and protecting our identities. Literacy links us with our past and with other members of the society as well. Narratives, stories, anecdotes and tales that we learn, consider important and can recall at any time, determine which values we regard as valuable or worthless. They are the basis for our judgement when we decide who are 'the good guys and the bad guys' in the process of constructing new stories through our experiences. Well-organized declarative knowledge

[10]About the knowledge base of democratic thinking see Csapó, 2001.

cannot be degraded to a secondary level.[11] Therefore, it is a basic task for schools to make the basic elements of literacy available for everyone. In connection with this it is important to mention that declarative knowledge is also involved in PISA assessment. Of course, this knowledge is essentially different from what we usually associate with school. Literacy is assessed and not expert knowledge.
The notion of literacy might be supported with numerous examples. Among others we may speak about literacy related to the humanities, music, the fine arts and techniques.
PISA assessments were conducted in a series fore planned over a long period of time. A basic objective was to get away as far as possible from the school context and to approach the realities of life instead (OECD, 2000). Elaboration of the notion of literacy was only the first step in this process. All three areas of literacy appearing in the assessment of 2000 were linked to some of the school subjects, or subject groups. At the same time cross-curricular competencies emerged. The additional questionnaire on self-regulated learning has already touched this cross-curricular aspect (OECD, 2003b), but the first cross-curricular competence to be assessed from the cognitive domain was the complex problem-solving in the assessment of 2003 (OECD, 2003a).

Competence

Finally, I turn to competence. The notion is quite frequently traced back to the basic work of Chomsky, the explication of linguistic competence. Although he primarily dealt with linguistics and psycho-linguistics, Chomsky is usually considered to be one of the forerunners and key figure of the cognitive revolution (see Gardner, 1985). He was the one to introduce a radical break-off with the then-dominant behaviourism. His basic assumption was that in each culture children acquire at least one language with considerable ease and safety. He thought it impossible that this language could be derived simply from experience, as there is a vast inequality between experiential input and the language finally produced by children. Linguistic knowledge is much more than we can acquire through observing the speech in our environment; therefore, the knowledge of language must have innate elements.

[11] For elaborated discussion of the importance of this type of knowledge see, for example Schank & Abelson, 1995; Bruner, 1996.

As early as at the beginning of the 1960s, after elaborating the conception of linguistic competence, Chomsky[12] raised the idea that his understanding of competence could be extended to other fields. Just like in the case of language, knowledge of other fields contains elements that cannot stem from mere experience. The organization of information and abilities into a psychologically appropriate order results in highly effective knowledge. A more widely applicable notion of competence was elaborated in the 1990s, and this notion seems to determine international (non-)academic processes and practices more and more.
In the case of competence, therefore, we face a psychologically determined system in which the ways of learning, the possibilities of development and improvement are largely based on innate schemes. In fact, what we see here is a mode of organizing skills and abilities into a particular kind of system in which a relatively small number of elements might be organized in an unlimited number of combinations. The development of competence happens largely spontaneously, through an interaction with the individual's environment. This sort of natural learning comes with ease and with high efficiency, however, teaching it – that is making an attempt to speed it up artificially– may be extremely difficult. Let us just imagine how easily a child acquires his or her mother tongue through natural interaction, and how easily children learn foreign languages in the native environment of the target language, while it is especially difficult to pass this same knowledge on to them trough vocabulary and grammatical rules.
As we see, competencies develop through natural acquisition most of the time. Everybody possesses a number of the most important competencies at some level. That is, if an individual with healthy psychical status goes through a certain minimal amount of interaction with the environment, competencies will develop to different extents. Still, there can be vast differences between developmental levels. In the end, the quality, frequency and amount of interactions determine the applicability and efficiency of a given competence. The development of competence is quite age-dependent, and young age has a primary role. For language development the first decade of human life is predominantly important; this is the period during which language competence develops. Unless one learns a language perfectly before adolescence, one will never speak that language without accent. Interestingly enough, this stands not only for living, spoken languages, but for artificially constructed languages as well. For instance, people with a hearing deficit, who cannot properly

[12] For an excellent summary of Chomsky's general views on cognition, see his Language and mind (Chomsky, 1968).

acquire sign language during their childhood, will use it with an 'accent' in their whole life.[13]
The ability to communicate is in itself a very important competence. Similarly, there exists a competence for the use of information technology. Essentially the point here, too, is the acquisition of complex symbolic systems. And, to present the validity of our general remarks regarding competence, it is enough to compare the performance of a child and an adult in front of a computer. Provided that both of them are beginners, the unsurpassable advantage of the young mind comes to light immediately. By observing the youth just exploring the computer we can understand Chomsky's astonishment over the development of language; it is really amazing how little information is enough for youngsters to decipher how the system works.
A characteristic feature of competence is that it is less content-dependent than expertise and literacy, which means that competencies are more widely transferable. Competencies are largely of an intensive character, their development is not simply a cumulative addition, rather a sort of 'strengthening'. Furthermore, competence is very much like the concept of fluid intelligence in psychometrics. This is the kind of intelligence that reaches the maximum of its development between 14-18 years of age, and after this time it hardly develops. The most important competencies are mother tongue, foreign languages, spatial perception and representation, and systems consisting of various cognitive operations.[14]
As mentioned before, the first important international assessment focusing on the competence of complex problem-solving took place in 2003. The expert group responsible for devising the theoretical framework began its work in April 2000 (Dossey, Csapó, De Jong, Klieme, & Vosniadou, 2000). The core of this work was defining what can be assessed as 'complex problem-solving' in the present school context. The team accepted the problem-solving conception of George Pólya (1945). According to Pólya, the process of problem-solving consists of five major steps, that, however, the team interpreted through a cognitive psychological approach. As for the areas of problem-solving, three major domains are distinguished: trouble-shooting, decision-making and system analysis and design.
Sadly enough, after a relatively short 'scientific career' the concept of competence fell prey to what many concepts have fallen prey to before:

[13] See Pinker`s classic on 'how the mind creates language' (Pinker, 1995).
[14] For some other approaches to competence (connectionist views and computational models) see Simon and Halford, 1995.

using it became a sort of fashion. This led to the twofold usage of the notion. On the one hand there is the notion of Chomsky, the scientific, psychological aspect on which my present analysis focuses. On the other hand one can experience an almost unlimitedly free usage of the term, leading to naming any phenomenon competence that might be accepted as 'cognitive' (and sometimes it goes as far as that it applies to anything psychological).
The problem is not the broad use of the term, but it would be of great benefit if at least professionals did not mix up the two different interpretations. Today most educational policy documents and other texts prepared for wider audiences contain a too general definition. Even the OECD-program '*Defining and Selecting Key Competencies*' shows such symptoms. In the first round of this, professionals defined competence from the viewpoint of their own field (Rychen & Salganik, 2001). The definitions were clear-cut and exact. Among others Wienert (2001) presented an excellent overview of the different possible interpretations of the concept of competence, and also discussed the problems of the many different meanings of this term. However, when in the second round educational institutions and organizations were asked to contribute – and finally three categories of key competencies were defined – the result was little more than philosophical commonplaces (Rychen & Salganik, 2003). Something similar happened to a EU committee that was given the task of interpreting 'basic skills' for common European framework. What the committee finally re-interpreted was its own mission; it turned to key competencies, of which they found eight.

The problem we face today is not a simple terminological confusion. In many European countries – especially in the Central- and Eastern-European educational systems –school education still focuses on the transmission of subject-matter knowledge. In a more or less efficient way, schools create expert-type knowledge, which is hardly utilized in everyday life. In the meantime, much less attention is paid to the development of students' competencies, just because among those who design and implement curricula, the concept of competence is much less known than the subject matter knowledge. Using the term competence too often or inadequately, does not solve, but rather hides the problems. Hopefully, this 'competence-fashion' will pass as quickly as it came, allowing professionals to concentrate on real issues and to fully exploit what the notion of competence really offers to education.

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